Development of Nutrient Criteria for Wyoming Streams and Lakes

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Wyoming Nutrient Work Group – March 11, 2014

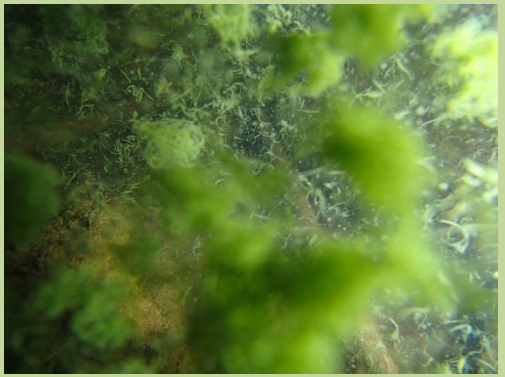
Outline

- Adverse impacts of nutrient pollution
- Approaches for developing nutrient criteria
- Advantages / Disadvantages of Approaches
- Multiple lines of evidence
- Wyoming data
- Current efforts
- Beyond the number...

Adverse impacts of nutrient pollution

(phosphorus, nitrogen, nitrates, ammonia)

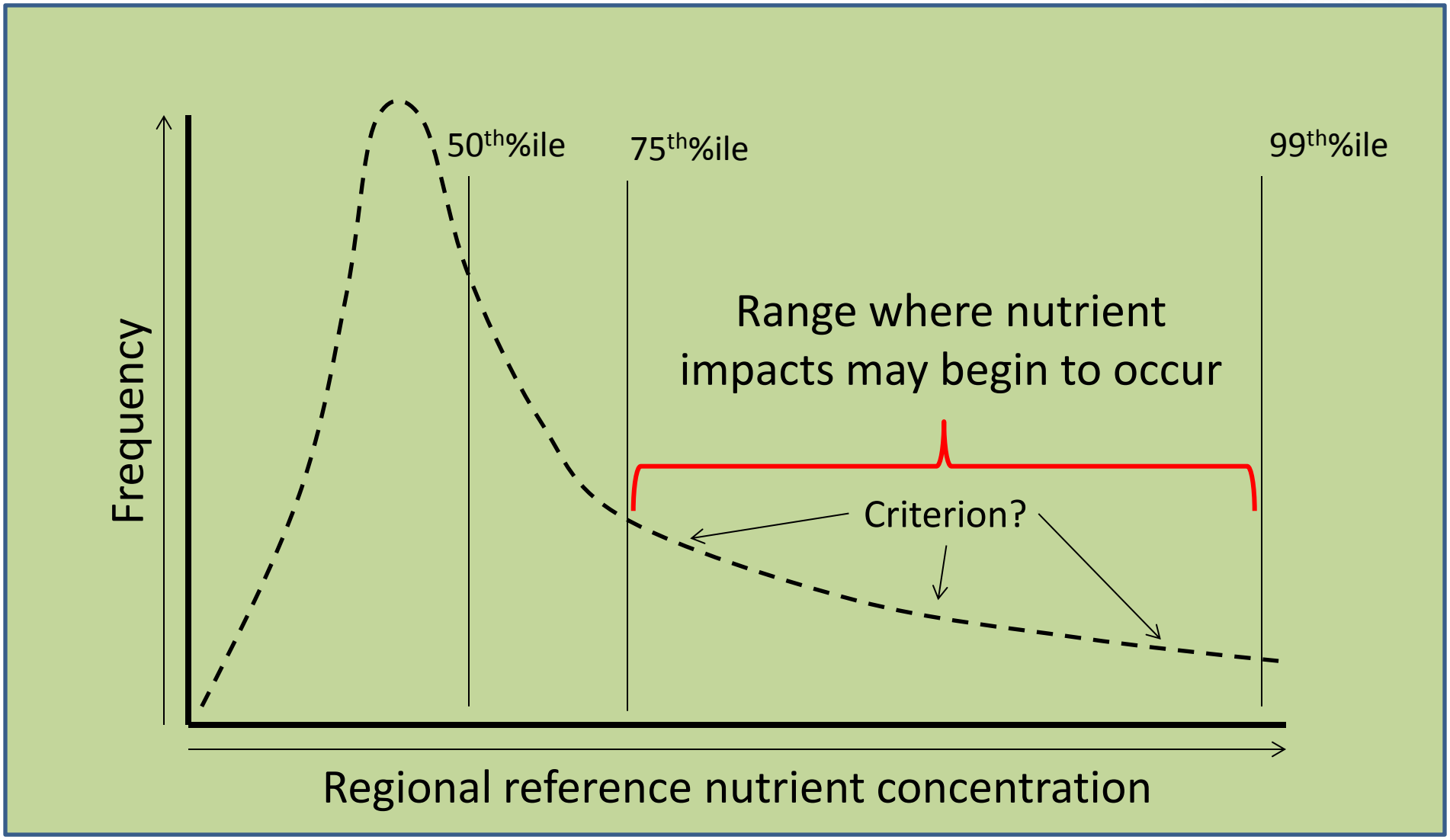
- Loss of water clarity, reduction in recreation and aesthetic quality
- Increased frequency of toxic algal blooms
- Decreased dissolved oxygen, increased pH
- Changes in fisheries and other aquatic life communities, fish kills
- Human health effects
- Taste and odor problems (drinking water)
- Interference with industrial, municipal and agricultural uses of water



Approaches for developing nutrient criteria

- Distributional / Reference
- Stressor-Response (effects based)
- Scientific literature
- Models
- Dose-response experiments

Distributional / Reference

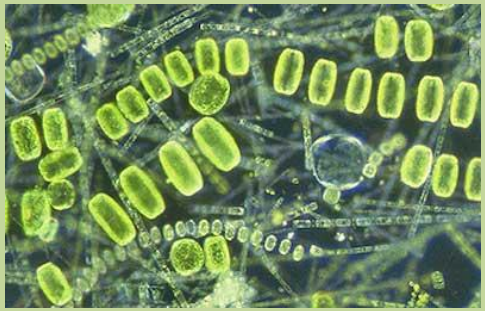


Distributional / Reference

- Advantages
  - Criteria derived from data collected in the region of interest – reflective of actual conditions

- Disadvantages
  - Relies on concentration data only – no direct link to use
  - May not reflect that biota can tolerate some degree of nutrient enrichment – potentially overprotective
  - Difficult to find reference conditions for some waters
  - Must establish reference network – resource intensive

Stressor-Response (effects based)



Oligotrophic

Low nutrient breakpoint

High nutrient breakpoint

Hypereutrophic

Biological Response

Criteria development range

Nutrient gradient

Stressor-Response (effects based)

- Advantages
  - Criteria derived from data collected in the region of interest – reflective of actual conditions
  - Provides direct link between criteria thresholds and the use being protected
  - Relationships can be used to predict responses

- Disadvantages
  - Potential for relationships to be highly variable
  - Analytical and resource intensive

Scientific Literature

- Established thresholds
- Known effect levels
- Starting points for criteria development

Comparing effects of nutrients on algal biomass in streams in two regions with different disturbance regimes and with applications for developing nutrient criteria

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SUGGESTED CLASSIFICATION OF STREAM TROPHIC STATE: DISTRIBUTIONS OF TEMPERATE STREAM TYPES BY CHLOROPHYLL, TOTAL NITROGEN, AND PHOSPHORUS

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DEVELOPING NUTRIENT TARGETS TO CONTROL BENTHIC CHLOROPHYLL LEVELS IN STREAMS: A CASE STUDY OF THE CLARK FORK RIVER

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Scientific Literature

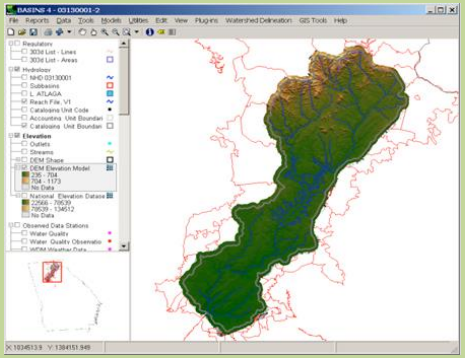
- Advantages
  - Economical, pre-defined, peer-reviewed
  - Defensible starting points for criteria development

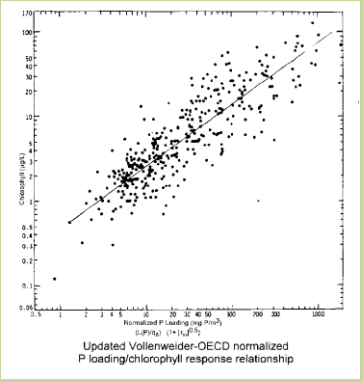
- Disadvantages
  - Varying applicability to waters
  - Potential to be over or underprotective of the use(s)
  - No direct link to the use being protected

Models

(Analytical approximations of the real system)

- Mechanistic
  - 'Pre-packaged' (Ex. QUAL2K, HSPF, WASP, SWAT, BASINS)
  - Models the biological, chemical and/or physical components of a system
  - Predictive
- Empirical (statistical-based)
  - Based on relationships among actual data (independent/dependent variables)
  - Predictive





Updated Vollenweider-OECD normalized P loading/chlorophyll response relationship

Models

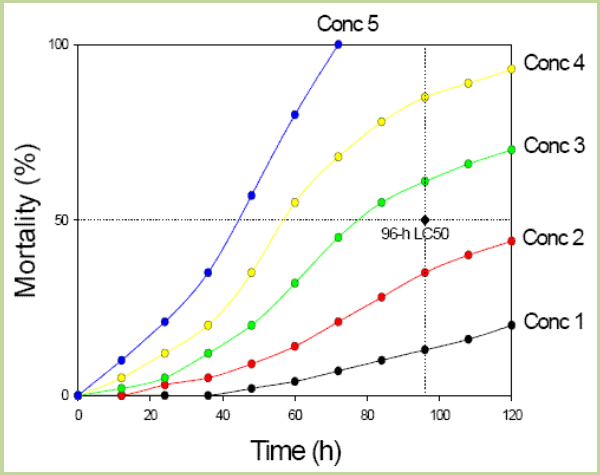
(Analytical approximations of the real system)

- Advantages
  - Predictive and powerful tools
  - Applicable to criteria development, assessment, TMDLs, effluent limit development, etc.

- Disadvantages
  - Potential uncertainty in predictions, inherent assumptions
  - No direct link to the use being protected
  - Data intensive, steep learning curve, complex, expensive

Dose-response experiments

- Observable data on the effects of organisms to varying doses of a pollutant
- Can evaluate lethal (acute) and sublethal (chronic) effects
- Laboratory or field-based
- Variables are controlled



Dose-response experiments

- Advantages
  - Criteria based on observable effect of biota to varying doses of pollutant – direct link to the use being protected

- Disadvantages
  - Difficult to account for other variables
  - Limited applicability – nutrients are generally not directly toxic
  - Expensive and resource intensive
  - Potential limitations in geographic applicability

Multiple Lines of Evidence

- Generate candidate endpoints from two or more approaches
- Weight endpoints based on advantages/disadvantages, best professional judgment, other
- Final criterion the result of multiple lines of evidence

Distribution/Reference

12 µg/L

Stressor-response

20 µg/L

Final criterion

19 µg/L

Scientific Literature

10 µg/L

Models

25 µg/L

Dose-response

18 µg/L

General Nutrient Criteria Development Strategy

- Criteria should reflect spatial variation (ecoregional, regional, watershed)
- Criteria should be specific for waterbody types
  - Rivers and streams
  - Lakes and reservoirs
- Criteria should reflect temporal variability
- Nutrient criteria should include
  - Causal variables (total phosphorus, total nitrogen)
  - Response variables (chlorophyll a, biological attributes)

- Goal: Develop scientifically defensible, protective and reasonable criteria for Wyoming

Wyoming Data

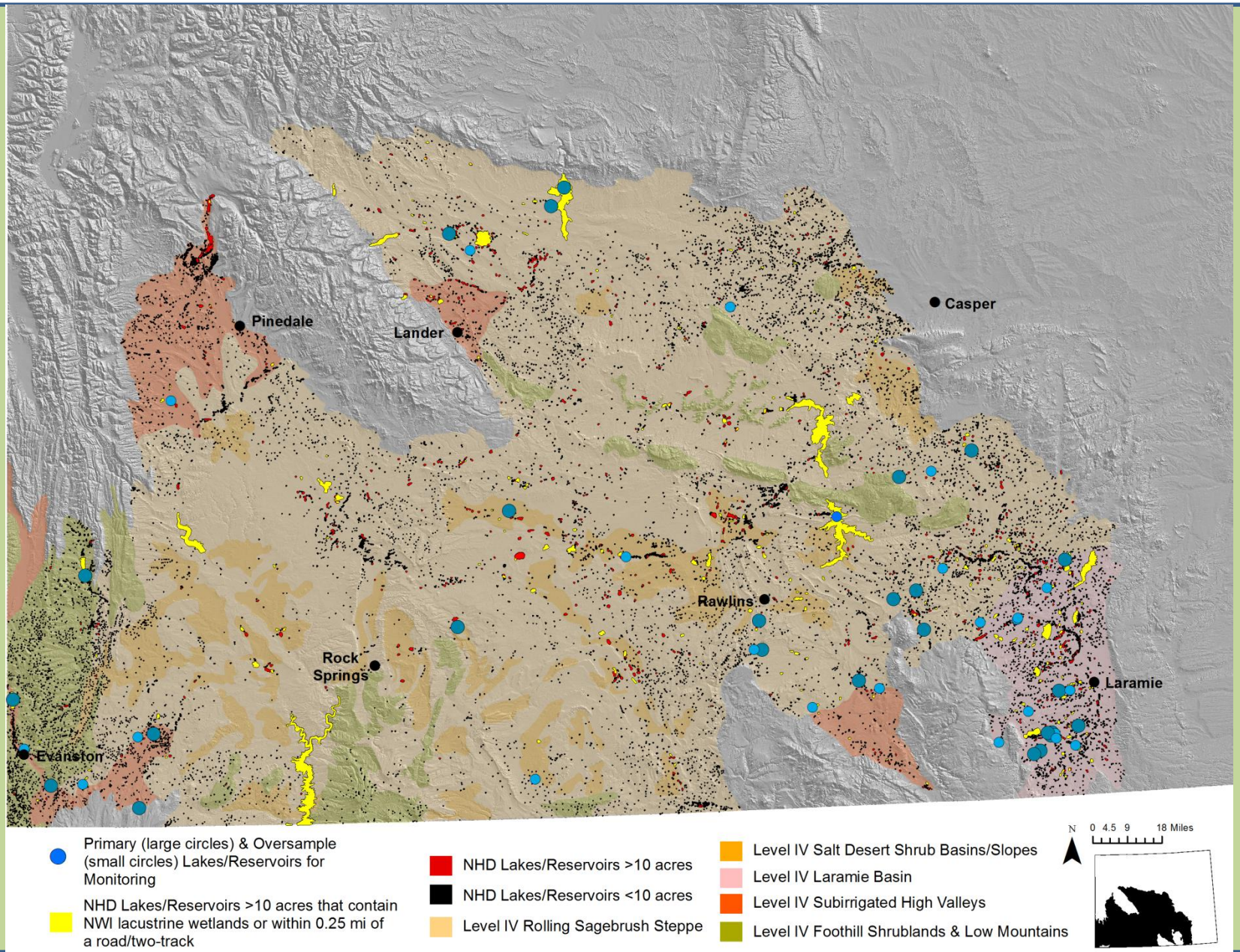
- Data range: Streams (1946-2013); Lakes (1937-2013)
- Sources: WDEQ, EPA, USGS, UW, NPS, WGFD, UDEQ, MDEQ
- WDEQ Nutrient Database developed
  - Compilation, Qa/Qc, data reduction/translation
- Spatial data: 418 lakes; 4,046 stream sites
- Water quality data
  - Total phosphorus, total nitrogen, nitrate+nitrite-N, ammonia-N, temp, DO, pH, redox, salinity, vertical profiles, chlorophyll a, secchi depth
  - Phytoplankton, periphyton, benthic macroinvertebrates (community diversity, composition, density)

Current Efforts

- WDEQ Nutrient data collection (biological, chemical, physical)
  - Streams (2005-present)
  - Lakes/Reservoirs (2002-present)

- Wyoming Basin Lakes & Reservoirs Nutrient Monitoring
  - Why Wyoming Basin? - Best existing data quantity/quality and distribution among regions (good starting point)
  - Objectives
    - Improve spatial/temporal data resolution and distribution
    - Various nutrient analytes and phytoplankton
    - Explore stressor-responses, classification, reference?
    - Initiated 2013, additional monitoring planned 2014+
    - 28 lakes sampled in 2013, 46 scheduled for 2014

Wyoming Basin Lake/Reservoir Nutrient Monitoring



Beyond the number...

- More to nutrient criteria development than coming up with the number(s)
- WDEQ with guidance from the stakeholder group will need to answer many questions that include:
  - How will criteria be written into standards (frequency/duration)?
  - How will we monitor for nutrient compliance?
  - How will we assess designated use support with respect to nutrients
  - How will we incorporate criteria into permits?
  - How do we factor in limits in treatment technology, economic considerations, funding?

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